

REMARKS - General

Applicant has rewritten claim 1 to define the invention particularly and distinctly so as to overcome the technical rejection and define the invention patentably over the reference art.

Applicant has rewritten claim 10 to incorporate the language of the original claim 1 and thus put it in allowable form as prescribed by the Office Action. Applicant requests reconsideration and allowance of claims 1 and 10 as amended, and of the remaining claims dependent on claim 1 as amended.

All claims except claim 10 were rejected as obvious based upon Steinmeyer et al in view of Funatsu, sometimes in view of other art in addition to Funatsu. The O.A. states that "Steinmeyer et al discloses applicant's basic inventive concept, a pulse tube cooler which has the cooling load contained within the envelope of the pressure vessel (the envelope of Steinmeyer is the cooling load)...." Applicant has amended Claim 1 to make it clear that the words "within the envelope" in claim 1 mean that the cooling load is enclosed by the pressure vessel, and that the cooling load does not include the pressure vessel itself. With that modification, Applicant submits that amended claim 1, and all of the claims dependent upon it, define patentably over the cited references, and any combination of those references. Applicant requests reconsideration of the rejection of claim 1 and the claims dependent on claim 1 for the following reasons:

1. None of the references cited in the O.A. suggests applicant's invention, either singly or in any operable combination. Moreover, there is nothing in any of the cited references that suggests the combination of any of these references with each other.
2. Even if Steinmeyer and Funatsu were combined, they would not show the novel physical features of applicant's invention.

3. All of the pulse tube references cited in the O.A. teach away from applicant's invention in that they all show a cooling load external to the working fluid of the cooler whereas applicant's invention shows the cooling load bathed in that working fluid.

4. Frank may not be considered as prior art because it was published after the filing date of applicant's application

5. Neither Miller nor Wurth could be operatively combined with Steinmeyer or Funatsu or with any combination of Steinmeyer and Funatsu.

6. Applicant's invention eliminates the cold heat exchanger and thermal link or bus found in prior art pulse tube coolers.

Steinmeyer is overcome by the amendment to Claim 1

Claims 1, 2, 5 and 11-14 were rejected as unpatentable over Steinmeyer in view of Funatsu. Applicant respectfully submits that neither Steinmeyer nor Funatsu suggests any combination of Steinmeyer with Funatsu that would read on applicant's invention. What Steinmeyer discloses is the possibility of using the pressure vessel envelope of a conventional pulse tube cooler as part of the electrical conduction path to get power from a room temperature conductor to a low-temperature superconducting device. Steinmeyer takes advantage of the fact that any operating pulse tube and any regenerator that is part of an operating pulse tube cooler, is necessarily colder at one end than at the other.

Steinmeyer's Fig. 1 and Fig. 2 show the cold end of the pulse tube cooler connected to a "thermal bus" 16 (Col. 4, l. 32). A thermal bus or link is a conventional arrangement for transferring heat from an external load through the thermal bus or link to the cold heat exchanger inside the pulse tube. See also Ravex Fig. 1 (thermal link 138 between cooled component 136 and cold heat exchanger 128); Pundak Fig. 1 (base plates 24 and 26 conduct heat from loads 12

and 14). Alternatives are loops of fluid to external loads. See Maguire et al, Fig. 1 (secondary pumped loop to cooling load) and Swift et al, (Pat. 6,637,211) Fig. 6B (self-pumping cooling loop to heat exchanger). Steinmeyer's contribution to the art is simply to employ the natural temperature gradient in the pulse tube and regenerator housings from their warm ends to their cold ends by using those housings (and possibly the regenerator matrix itself) as electrical conductors. The presence of the "thermal bus" shows that an external cooling load is cooled in the conventional manner by conduction through the thermal bus.

Steinmeyer's Fig. 1 and Fig. 2 do not label the cold heat exchangers of those pulse tube coolers, but Steinmeyer's Fig. 3 and Fig. 4 show the same structure as Figs. 1 and 2 and identify the cold heat exchanger as "39" (Col. 5, ll. 41-43) at the bottom end of the pulse tube. That cold heat exchanger connects to "regenerator 6" in Fig. 1 and "regenerator 26b" in Fig. 2 through "insulating overflow line 15". Those cold heat exchangers are adjacent to and in contact (through the pulse tube housing) with "thermal bus 16" in Figs. 1 and 2. That is the traditional means for cooling a load with a pulse tube cooler, as shown in Fig. 1 (prior art) in the instant application. Steinmeyer's "thermal bus 16" is external to the cold heat exchanger, exposed to the ambient air (or vacuum). That is the opposite of applicant's arrangement, in which the load is internal, and bathed in the high-pressure operating fluid of the cooler. Steinmeyer has a cold heat exchanger and thermal bus, whereas applicant's invention eliminates both components.

Steinmeyer does not depart in any relevant way from the conventional structure inside the envelope of the pulse tube. The cold heat exchanger occupies one end of the pulse tube, and the warm heat exchanger ("38" in Figs. 3 and 4) occupies the other end. The cold heat exchanger ("39" in Figs. 3 and 4) is directly connected to the regenerator through "electrically insulating overflow line 15" (Figs. 1, 2; col. 4, l. 30). If the cooler is to function properly, the heat

exchangers at both ends of the pulse tube will distribute flow entering the pulse tube evenly across its cross section.

Nothing in Steinmeyer or Funatsu (or any other reference mentioned in the O.A.) suggests that Steinmeyer's "electrically insulating overflow line 15" could be replaced by a large, irregularly-shaped cooling load and that the cold heat exchanger could be replaced with a flow straightener that does not also serve as a cold heat exchanger.

Applicant's original Claim 1, on which all other claims were dependent, claimed a pulse tube cooler in combination with a cooling load wherein "said cooling load is contained within the envelope of the pressure vessel...." That language could be construed to include the envelope of the pressure vessel itself as part the cooling load. Claim 1 is accordingly amended to make it clear that the cooling load is located inside the inner wall of the pressure vessel, between the regenerator and a flow straightener. That is contrary to the arrangement of Steinmeyer in which the load connected to thermal bus 16 is entirely external to the inner wall of the pressure vessel. Applicant's arrangement is contrary to the accepted arrangement of prior art pulse tube coolers as shown in all the pulse tube references.

Funatsu adds nothing of substance to Steinmeyer

Funatsu's contribution adds nothing to Steinmeyer, or any other conventional pulse tube arrangement, except for the conical shape of multiple parallel passages in the warm and cold heat exchangers at the ends of the pulse tube. Combining Steinmeyer with Funatsu would either mean using the housing of Funatsu's pulse tube cooler as an electrical conductor or replacing Steinmeyer's heat exchangers with Funatsu's heat exchangers. Either combination is still a conventional pulse tube cooler. Neither combination suggests applicant's invention.

All prior pulse tube art has assumed that the cold heat exchanger of the pulse tube will be inside the envelope of the pressure vessel, adjacent to the regenerator, and that heat will pass into a pulse tube cooler from an external heat load through that heat exchanger. Design of heat exchangers at the warm and cold ends of the pulse tube has been constrained by the need to maintain smoothly stratified flow within the pulse tube itself. Funatsu represents one such design; the emphasis in Funatsu is on the unusual tapered configuration of flow passages through the hot and cold heat exchangers, but their principal function remains that of heat exchangers. Funatsu's drawings do not show the cooling load, but the text recites that "...a substance (not shown) mounted on the cold head 11 is set to be cooled down...." (Col. 2, ll. 51-53). That, again, is the traditional cooling load arrangement, with the load external to the envelope of the cooler as described.

The insight presented by this application is that that need not be so. Instead, the cold heat exchanger can be dispensed with and a cooling load of widely varying size and shape can be put into the space otherwise occupied by the cold heat exchanger so long as some flow-straightening means is interposed between the cooling load and the empty volume of the pulse tube.

The Dependent Claims are A Fortiori Patentable over Steinmeyer and Funatsu.

As explained above, claim 1 as amended is patentable over Steinmeyer and Funatsu. Claims dependent upon claim 1 add additional limitations on the scope of claim 1 and are *a fortiori* patentable when claim 1 is patentable. None of the additional art cited with respect to those claims can therefore bar their patentability.

Frank Teaches away from Applicant's Invention

Claims 3 and 4 are rejected on Steinmeyer, Funatsu and Frank et al. But Frank was first published on July 28, 2005 and cannot be considered prior art with respect to this application, which was filed on March 26, 2004.

In any event, Frank teaches away from applicant's invention. In Frank, the separate cooler's cold head 16 "...makes good contact with a refrigerant condenser unit.... This condenser unit is connected to a ...heat pipe 20 which projects into the [rotating device]." (Para. 0031). As succinctly explained in paragraph 0009 of Frank, "the cold head should be located in a fixed manner outside the rotor and thermally connected to a condenser unit for condensation of a refrigerant." In other words, Frank again demonstrates a way of cooling an object external to the pressure vessel of the cold head of the cooling engine using a heat pipe. Frank also teaches cooling a rotating machine by transmitting a secondary coolant into a sealed cavity inside the machine. Applicant's approach is to bathe the entire machine in the operating fluid of the cooling machine itself.

Thus Frank joins Steinmeyer, Funatsu, Ravex, Pundak, Maguire and Swift in demonstrating different methods of cooling a cooling load located outside the envelope of the pulse tube cooler - the reverse of applicant's approach.

Miller could not be operatively combined with Steinmeyer or Funatsu

Claim 6, relating to electronic components, was rejected on Steinmeyer and Funatsu in further view of Miller. However, Miller shows an approach to cooling electronic components using a cold fluid that flows continuously in one direction over the components. Nothing in Miller suggests that the cold fluid is the operating fluid of the cooling engine that makes the fluid cold. But even if that were true, the essential operating principle of the pulse tube cooler is that

flow in the operating fluid must cyclically reverse directions. Incorporating Miller's unidirectional coolant flow into the pulse tube cooler of either Steinmeyer or Funatsu would disable it.

Urano and Pundak teach away from applicant's invention

Claims 7-9, relating to electro-optical devices, were rejected on Steinmeyer and Funatsu in further view of Urano et al or Pundak. However, as noted above, all of those references teach away from applicant's inventive concept. In every instance, a cooling load external to the working fluid of the cooler is cooled by a heat exchanger that absorbs heat from the load and delivers it through the wall of the pressure vessel of the cooler. Applicant places the cooling load right in the working fluid of the cooler and eliminates the cold heat exchanger. Nothing in those references, singly or in any combination, suggests applicant's approach, which is diametrically opposite to the heat transfer approach revealed in all of them.

The O.A. refers to the paragraphs 60 and 66 of Urano to show that cooling an infrared sensor or focal plane array is old art. Paragraph 66 of Urano states that "...the use of liquid nitrogen, Stirling cooling or pulse tube cooling is desirable...." But there is no suggestion that the cooled object should be immersed in the working fluid of the cooling engine, whether it be the Stirling cooler, the pulse tube cooler, or whatever cooler has been employed to liquefy the nitrogen. Cooling infrared sensors is indeed old art; applicant's advance is to show that infrared sensor can be placed inside the pulse tube cooler in the space otherwise occupied by the cold heat exchanger so long as some means such as screens is employed to smooth out the flow entering the pulse tube at its cold end.

As noted above, Pundak cools electronics filters on flanges that are external to the cold head that cools them. Applicant's advance is to eliminate the cold heat exchanger and the external flange by putting the electronic components right inside the pulse tube.

The "pertinent" art reinforces the non-obviousness of applicant's invention

Other art deemed "pertinent," although not relied upon, demonstrates that applicant's invention was not obvious to still more inventors other than those whose inventions were relied upon for rejections. As the abstract of Reid makes clear, "the invention employs a working or 'active' fluid and a heat transfer fluid which are physically separated." (Emphasis added)

Applicant's invention uses the working fluid of the cooler as the heat transfer fluid, eliminating the need for a second "heat transfer fluid."

Bennett shows a thermoacoustic cooler in which a common housing contains both the cooling engine and the cooled electronics, but they are separated by a partition so that the electronics are not in contact with the working fluid of the thermoacoustic cooler. Instead, a heat pipe draws heat from the electronics in one compartment and conveys it to the cold heat exchanger of the thermoacoustic cooler in a separate compartment. As in Steinmeyer, Funatsu, Urano, Pundak and Reid, the cooling load is external to the pressure vessel that contains the working fluid of the cooler.

Ravex and Kunitani likewise show pulse tube coolers, and in each instance the cooling load is external to the pressure vessel containing the working fluid. Thus these references further support the non-obviousness of applicant's invention.

Wurth employs a vapor-cycle refrigerator that is completely different from the gas cycle in pulse tube coolers. The flow in Wurth is unidirectional, as in Miller. Moreover, the cycle requires continuous evaporation of a two-phase fluid in one part of the system and condensation

in another part. Pressure at each point in the loop is more or less constant. In contrast the fluid in the pulse tube cooler undergoes cyclical change of direction of flow, never condenses and experiences cyclically varying pressure throughout the cycle and throughout all parts of the cooler. In relation to a pulse tube cooler, to use a baseball analogy, Wurth's arrangement is somewhere out in deep left field.

The legal test of obviousness

As stated in In re Johnson, ___ F3d___; ___USPQ2d ___ (Fed Cir 2006), "[T]o find a combination obvious there must be some teaching, suggestion, or motivation in the prior art to select the teachings of separate references and combine them to produce the claimed combination."

In Princeton Biochemicals, Inc. v. Beckman Coulter, Inc., 411 F3d 1332; ___USPQ2d ___ (Fed Cir 2005), the court stated the test as follows: "[S]imply identifying all of the elements in a claim in the prior art does not render a claim obvious. Instead section 103 requires some suggestion or motivation in the prior art to make the new combination." (411 F3d at 1339; ___USPQ2d at ___).

As expounded in Ex Parte Levengood, 28 U.S.P.Q.2d 1300 (P.T.O.B.A&I. 1993),

"In order to establish a *prima facie* case of obviousness, it is necessary for the examiner to present *evidence*, preferably in the form of some teaching, suggestion, incentive or inference in the applied prior art, or in the form of generally available knowledge, that one having ordinary skill in the art *would have been led* to combine the relevant teachings of the applied references in the proposed manner to arrive at the claimed invention.... That which is within the capabilities of one skilled in the art is not synonymous with obviousness.... That one can *reconstruct* and/or explain the theoretical

mechanism of an invention by means of logic and sound scientific reasoning does not afford the basis for an obviousness conclusion unless that logic and reasoning also supplies sufficient impetus to have led one of ordinary skill in the art to combine the teachings of the references to make the claimed invention....Our reviewing courts have often advised the Patent and Trademark Office that it can satisfy the burden of establishing a *prima facie* case of obviousness only by showing some objective teaching in either the prior art, or knowledge generally available to one of ordinary skill in the art, the 'would lead' that individual 'to combine the relevant teachings of the references.'... Accordingly, an examiner cannot establish obviousness by locating references which describe various aspects of a patent applicant's invention without also providing evidence of the motivating force which would impel one skilled in the art to do what the patent applicant has done."

Here, all of the pulse tube references point in the opposite direction from applicant's invention in that they search for better ways to design a cold heat exchanger (e.g. Funatsu, Swift) or better ways to hook up a cold heat exchanger to an external cooling load (Steinmeyer, Pundak, Raves, Frank, Bennet, Kunitani, Reid). None suggest applicant's invention.

CONCLUSION

For all of the reasons stated above, applicant submits that the claims are now in proper form and that they all define patentably over the prior art. Therefore, applicant submits that this application is now in condition for allowance, which action he respectfully requests.

Conditional Request for Constructive Assistance

If, for any reason, this application is not believed to be in full condition for allowance, applicant respectfully requests the constructive assistance and suggestions of the Examiner

pursuant to M.P.E.P. § 2173.02 and § 707.07 in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

INTERVIEW SUMMARY:

A telephonic interview between William C. Doerrler, Examiner, and Matthew P. Mitchell, Applicant, took place on 03 October, 2006, as follows:

1. No exhibits were shown nor was any demonstration conducted.
2. No claims were discussed.
3. It was pointed out by the Applicant that the Frank reference in the Office Action was not listed on the 892 or the PTO/SB/08A forms then of record. The Frank reference was given over the telephone by the Examiner as 2005/0160744. It was also confirmed by the Examiner, in response to Applicant's question, that the Worth patent in the "further art of interest" refers to the Wurth patent listed in the 892 attached to the first Office Action.
4. No proposed amendments were discussed.
5. No arguments were presented to the Examiner.
6. No other pertinent matters were discussed.
7. The Examiner indicated that the Frank reference would be made of record.

Very respectfully,

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I hereby certify that this correspondence, and attachments, if any, will be deposited with the United States Postal Service by First Class Mail, postage prepaid, in an envelope addressed to "Box Non-Fee Amendments, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450" on the date below:

Date: 25 October 2006

Inventor's Signature: Matthew P. Mitchell